

SPECIFICATION

To All Whom It May Concern:

Be It Known That I, WILLIAM O. HUBBS being a citizen of the United States and residing in the County of Jefferson, State of Missouri, whose post office address is, 6274 Rocky grove, P.O. Box 540, Cedar Hill, Missouri 63016, has invented new and useful improvements in

**DISPLACEMENT PROCESS FOR HOLLOW
SURVEYING RETROREFLECTOR**

CROSS-REFERENCE TO RELATED APPLICATIONS

This regular letters patent application claims priority to provisional patent application having Serial No. 60/443,268, which was filed on January 30, 2003.

BACKGROUND OF THE INVENTION

This invention relates to retroreflectors, and more particularly to hollow retroreflectors used with surveying equipment.

Surveying equipment currently use light rays (i.e., lasers) to perform the measuring and calculating functions required when surveying. Surveying retroreflectors are used to receive an incident light ray and reflect that ray along a parallel path back to its source. Some surveying equipment detects the return of the light ray and, from the elapsed time, determine the distance between the source and the retroreflector. Because the light ray is reflected back to its source, the retroreflector must be made very accurately and to very close tolerances.

Some surveying equipment use hollow retroreflectors. One example of a hollow retroreflector is shown in U.S. Pat. No. 5,122,901, which is owned by PLX, Inc. and sold under the name "Omni-Wave". The hollow retroreflector shown in this patent uses three reflecting panels which are set in a receptacle. The receptacle is then received in an outer casing. The reflecting panels are made of glass and have a reflective coating applied thereto. Because of the precision that is required, the three glass panels must be very accurately set in the receptacle. The precision and accuracy required of the hollow retroreflector makes this retroreflector very expensive and time consuming to produce. Further, because glass is used, it is fragile.

Opticon, of Billerica, MA produces another hollow retroreflector which uses an aluminum substrate rather than a glass substrate. The Opticon retroreflector uses a male master coated with a releasing agent and a reflective

coating. A bonding agent is applied to the coating on the master, or on the surfaces of the part to which the reflective coating is to be applied. The master and the part are then brought together to bond the reflective coating to the aluminum substrate. This hollow retroreflector is also very expensive and time consuming to produce. Additionally, the reflective coating may not transfer well, leaving voids or finishes which are unacceptable.

BRIEF SUMMARY OF THE INVENTION

A one-piece hollow retroreflector is formed in a cylindrical body, or other shape, in a punch press operation. A punch having a cube corner configuration is used to punch a reflecting chamber having three mutually orthogonal surfaces into the cylinder. The chamber walls might be coated with a clear preservative to prevent corrosion of the surfaces. The retroreflector is formed from a malleable and reflective material. After the reflecting chamber has been formed and finished, the body of the retroreflector can be machined to remove the displaced material and otherwise form the outer surfaces of the body to a desired shape.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1 is a top plan view of a hollow retroreflector of the present invention;

FIG. 2 is a perspective view of a punch used to produce the hollow retroreflector; and

FIG. 3 is an elevational view of a punch press in which a retroreflector blank and the punch are mounted to produce the hollow retroreflector; and

FIG. 4 is an isometric view of the hollow retroreflector of the present invention.

Corresponding reference numerals will be used throughout the several figures of the drawings.

DETAILED DESCRIPTION OF THE INVENTION

The following detailed description illustrates the invention by way of example and not by way of limitation. This description will clearly enable one skilled in the art to make and use the invention, and describes what I presently believe is the best mode of carrying out the invention.

A hollow retroreflector 1 of the present invention is shown in FIG. 1. The retroreflector 1 is made from a solid piece of malleable material and hence is a one-piece retroreflector. The malleable material can be of a material that provides a highly reflective surface, such as lead, or other highly reflective metals. The retroreflector 1 has a body 3 which is preferably cylindrical, and hence has a circular side wall 5 and flat top and bottom surfaces 7. A reflective chamber 9 is formed in the top surface of the body 3. The chamber 9 has three walls 11a, b, c which are mutually orthogonal to each other and define a corner of a cube. That is, the junctions between walls 11a and 11b, between 11b and 11c, and between 11c and 11a are all 90°. The corners are all as sharp as possible, so as not to create a radius at the corners or apex.

The chamber 9 is formed in a blank cylinder using a forming punch 21 in a method similar to a punch press type operation. The punch 21 is shown in FIG. 2 has an end or tip 23 of the desired shape and size. As can be appreciated, the punch tip 23 forms a corner of a cube. The punch 21 and a blank 1' are placed in a press 25, as seen in FIG. 3. The blank 1' is mounted on a base of the press 25 and the punch 21 is mounted in a movable jig of the press. The punch 21 is pressed down and material is displaced from the blank 1' to form the reflective chamber 9. Once the chamber 9 is formed, the excess or displaced material can be machined away to give the required outside finish size or shape to the reflector body 3.

The chamber 9 can be formed in a single pressing operation, but may require a rough punching operation and then a finish punching operation. The

finish punch and rough punch would essentially be the same size and shape. However, the finish punch would be made of a material that will produce a reflective finish on the walls of the chamber 9. The finish punch can be made from hardened steel.

Once the chamber 9 has been formed, a clear protective coating may be applied to the surface of the walls 11a-c to prevent corrosion of the metal body 3.

The hollow retroreflector has several advantages over the prior known retroreflectors. It is made as a one-piece member made in a punching operation and requires no assembly. Hence, it is less expensive to manufacture. Further because it is one piece member, it is more resistant to damage, and because it has no glass, it is not breakable. Again, because there is no assembly, there will be a lower rejection rate – the only variable would be the ware or damage imposed on the finish punch. The internal shape of the chamber 9 can be easily altered by simply producing new punches.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.